CLAIMS

1.   An image processing apparatus comprising:

an image obtaining unit that obtains an image captured
with an image sensor; and

5   a defect information generating unit that generates
defect information indicating a defect within the image having
been obtained, based upon a value at a target pixel and an
average value of a plurality of pixel values corresponding
to pixels present within a predetermined range containing the
10   target pixel.

2.   An image processing apparatus according to claim 1,
wherein:

the defect information generating unit includes a
15   relative ratio calculation unit that calculates a relative
ratio of the value at the target pixel and the average value
of the plurality of pixel values corresponding to the pixels
present within the predetermined range containing the target
pixel, and generates the defect information based upon the
20   calculated relative ratio.

3.   An image processing apparatus according to claim 1 or
claim 2, wherein:

the defect information generating unit generates defect
25   information for an area within the image, which satisfies a

predetermined condition.

4.   An image processing apparatus according to any of claims 1 through 3, further comprising:

a correction unit that corrects the defect within the image based upon the defect information.

5.   An image processing apparatus according to claim 2, further comprising:

a correction unit that corrects the defect within the image based upon the defect information, wherein:

the correction unit corrects the defect by multiplying a value at a corresponding pixel by a reciprocal of the relative ratio.

6.   An image processing apparatus according to claim 1, wherein:

the image obtaining unit obtains a plurality of images captured with the image sensor; and

the defect information generating unit generates defect information indicating a defect within one of the plurality of images by using the plurality of images having been obtained.

7.   An image processing apparatus according to claim 1, wherein:

the image obtaining unit obtains a plurality of images captured with the image sensor; and

the defect information generating unit generates defect information corresponding to an entire image of each of the plurality of images by using the plurality of images having been obtained.

8.   An image processing apparatus comprising:

an image obtaining unit that obtains a reference image photographed through an optical system; and

a defect information generating unit that generates defect information indicating a defect within the reference image having been obtained, based upon a value of a target pixel and an average value of a plurality of pixel values corresponding to pixels present within a predetermined range containing the target pixel in the reference image.

9.   An image processing apparatus according to claim 8, wherein:

the defect information generating unit includes a relative ratio calculation unit that calculates a relative ratio of the value at the target pixel and the average value of the plurality of pixel values corresponding to the pixels present within the predetermined range containing the target pixel, and generates the defect information based upon the

calculated relative ratio.

10.   An image processing apparatus according to claim 8 or claim 9, wherein:

      the image obtaining unit obtains a correction target image photographed through the optical system; and

      there is further provided a correction unit that corrects a defect within the correction target image based upon the defect information within the reference image.

11.   An image processing apparatus according to claim 10, wherein:

      if the reference image and the correction target image have been photographed through an optical system in substantially identical optical conditions with regard to an aperture value and a pupil position, the correction unit corrects a value at a pixel constituting the correction target image by directly using the defect information having been generated.

12.   An image processing apparatus according to claim 10, further comprising:

      a defect information conversion unit that converts the defect information in correspondence to at least either of an aperture value and a pupil position constituting optical

conditions of the optical system, wherein:

if the reference image and the correction target image have been photographed through the optical system under different optical conditions with regard to at least either

5 the aperture value or the pupil position, the correction unit corrects a value at a pixel constituting the correction target image by using the converted defect information.

13. An image processing apparatus according to claim 9,
10 further comprising:

a correction unit that corrects a value of a corresponding pixel in the correction target image by multiplying the value of the corresponding pixel with a reciprocal of the relative ratio calculated for the reference
15 image.

14. An image processing apparatus according to claim 2 or claim 9, wherein:

the relative ratio calculation unit sets the calculated
20 relative ratio to 1 if the calculated relative ratio falls within a predetermined range containing 1.

15. An image processing apparatus according to claim 14, wherein:

25   the relative ratio calculation unit correlates the

predetermined range over which the calculated relative ratio
is set to 1 with a standard deviation value of the calculated
relative ratio.

5   16.   An image processing apparatus according to claim 1 or
claim 8, wherein:
        the predetermined range containing the target pixel is
greater than a defect area manifesting within the image or
the reference image.

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17.   An image processing apparatus according to claim 10,
wherein:
        the image obtaining unit obtains a reference image
photographed within a predetermined period of time preceding
15   or following a time point at which the correction target image
is photographed.

18.   An image processing apparatus according to claim 17,
wherein:
20   the image obtaining unit obtains a reference image
photographed at a time point closest to or second closest to
a time point at which the correction target image is
photographed.

25   19.   An image processing apparatus comprising:

an image obtaining unit that obtains an image captured by using an image sensor capable of separating light into a plurality of colors;

a luminance signal generating unit that generates a luminance signal based upon signals of the plurality of colors constituting the image ; and

a defect information generating unit that generates defect information indicating a defect within the image based upon the luminance signal for the image having been generated.

20. An image processing apparatus according to claim 19, further comprising:

a correction unit that corrects a value corresponding to a color component at a defective pixel within the image by using the defect information.

21. An image processing apparatus according to claim 19, further comprising:

a defect information generating unit that generates defect information indicating a defect within the image having been obtained based upon a value indicated by the luminance signal generated for a target pixel and an average value among values indicated by luminance signals generated for a plurality of pixels within a predetermined range containing the target pixel.

22. An image processing apparatus according to claim 21, wherein:

the defect information generating unit includes a relative ratio calculation unit that calculates a relative ratio of the value indicated by the luminance signal generated for the target pixel and the average value of the luminance signals generated for the plurality of pixels within the predetermined range containing the target pixel, and generates the defect information based upon the relative ratio having been calculated.

23. An image processing apparatus according to claim 21, further comprising:

a correction unit that corrects a value corresponding to a color component at a corresponding pixel by multiplying the value by a reciprocal of the relative ratio.

24. An image processing apparatus according to claim 19, wherein:

the image obtaining unit obtains a plurality of images photographed with the image sensor;

the luminance signal generating unit generates the luminance signals for the plurality of images having been obtained; and

the defect information generating unit generates defect information indicating a defect within an image among the plurality of images by using the luminance signals generated for the plurality of images.

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25.   An image processing apparatus according to claim 19, wherein:

the image obtaining unit obtains a plurality of images photographed with the image sensor;

10   the luminance signal generating unit generates luminance signals for the plurality of images having been obtained; and

the defect information generating unit generates defect information corresponding to an entire image of each of the

15   plurality of images by using the plurality of images having been obtained.

26.   An image processing apparatus according to claim 1, wherein:

20   the image sensor captures an image through an optical system; and

the defect information is information on a projected image of a defect within an optical path, which manifests in the image.

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27.   An image processing apparatus according to claim 26,
wherein:

        the defect information generating unit simultaneously
generates information indicating a position of the projected
image of the defect within the optical path and information
indicating intensity of the projected image of the defect
within the optical path and records the position information
and the intensity information.

28.   An image processing apparatus according to claim 27,
wherein:

        the defect information generating unit moves the
predetermined range over which the average value is calculated
for each target pixel and generates continuous sets of
information related to the intensity of the projected image
of the defect within the optical path.

29.   An image processing apparatus according to claim 4,
wherein:

        the correction unit determines a correction value by
using an initial-signal value indicated at a correction target
pixel position.

30.   An image processing apparatus according to claim 8,
wherein:

the defect information is information on a projected image of a defect within an optical path, which manifests in the image.

5   31.   An image processing apparatus according to claim 30, wherein:

the defect information generating unit simultaneously generates information indicating a position of the projected image of the defect within the optical path and information

10   indicating intensity of the projected image of the defect within the optical path and records the position information and the intensity information.

32.   An image processing apparatus according to claim 31,

15   wherein:

the defect information generating unit moves the predetermined range over which the average value is calculated for each target pixel and generates continuous sets of information related to the intensity of the projected image

20   of the defect within the optical path.

33.   An image processing apparatus according to claim 10, wherein:

the correction unit determines a correction value by

25   using an initial signal value indicated at a specific

correction target pixel position.

34.   An image processing apparatus according to claim 15,
wherein:

5   the relative ratio calculation unit sets the
predetermined range over which the calculated relative ratio
is set to 1 to a ± (3 x standard deviation value) range.

35.   An image processing apparatus according to claim 26,
10   wherein:

the predetermined range containing the target pixel is
greater than a range over which the projected image of the
defect within the optical path spreads inside the image.

15   36.   An image processing apparatus according to claim 30,
wherein:

the predetermined range containing the target pixel is
greater than a range over which the projected image of the
defect within the optical path spreads inside the reference
20   image.

37.   An image processing apparatus comprising:
an image obtaining unit that obtains a first image
photographed through an optical system and a second image
25   photographed under optical conditions different from optical

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conditions in which the first image is photographed; and

a defect information generating unit that generates defect information indicating a defect in the first image or the second image by using the first image and the second image.

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38.   An image processing apparatus according to claim 37, further comprising:

a correction unit that corrects a defect in the first image or the second image by using the defect information.

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39.   An image processing apparatus according to claim 37, wherein:

the first image and the second image are photographed under different optical conditions with regard to at least

15   either of an aperture value and a pupil position.

40.   An image processing apparatus according to any of claims 37 through 39, wherein:

the defect information generating unit includes an

20   optical condition conversion unit that converts at least either the first image or the second image so as to conform to a specific optical condition, in order to eliminate a mismatch of the optical conditions for the first image and the second image.

25   41.   An image processing apparatus according to claim 40,

wherein:

if the optical conditions with regard to the aperture value are different, the optical condition conversion unit executes low pass filter processing on a pixel signal generated based upon the first image or the second image so as to convert a defect state corresponding to the first image or the second image to a defect state estimated to manifest at a matching aperture value.

42. An image processing apparatus according to claim 41, wherein:

the optical condition conversion unit executes conversion by using a substantially uniformly weighted low pass filter.

43. An image processing apparatus according to claim 40, wherein:

if the optical conditions with regard to the pupil position are different, the optical condition conversion unit executes displacement processing through which a pixel signal generated based upon the first image or the second image is displaced from a center of an optical axis of the optical system along a direction of a radius vector so as to covert a defect state corresponding to the first image or the second image to a defect state estimated to manifest at a matching pupil

position.

44.   An image processing apparatus according to claim 43, wherein:

the optical condition conversion unit executes displacement processing through which a pixel signal located further away from the center of the optical axis is shifted to a greater extent along the radius vector.

45.   An image processing apparatus according to claim 43 or claim 44, wherein:

the optical condition conversion unit executes the displacement processing by executing an arithmetic operation to predict an extent of displacement on an assumption that foreign matter causing the defect is present over a specific distance from an image-capturing surface within the optical system along the optical axis.

46.   An image processing apparatus according to claim 37, wherein:

one of the first image and the second image is a correction target image to undergo correction and the other image is a reference image used to generate the defect information.

47.   An image processing apparatus according to claim 37,

wherein:

the first image and the second image are both correction target images to undergo correction; and

the defect information generating unit generates defect information to be used commonly in conjunction with the first image and the second image by using the first image and the second image.

48. An image processing apparatus according to claim 47, wherein:

the defect information generating unit includes an optical condition conversion unit that converts at least either the first image or the second image so as to conform to a specific optical condition, in order to eliminate a mismatch of the optical conditions for the first image and the second image.

49. An image processing apparatus according to claim 46, wherein:

the image obtaining unit obtains the reference image photographed at an aperture value corresponding to a narrowest aperture opening setting in an adjustable aperture value range of the optical system.

50. An image processing apparatus according to claim 37, wherein:

the defect information generating unit generates defect
information indicating a defect within the image having been
obtained, based upon a value of a target pixel and an average
value of a plurality of pixel values corresponding to pixels

5   present within a predetermined range containing the target
pixel in the image.

.51.   An image processing apparatus according to claim 46 or
claim 49, wherein:

10   the image obtaining unit obtains a reference image
photographed within a predetermined period of time preceding
or following a time point at which the correction target image
is photographed.

15 52.   An image processing apparatus comprising:
            an image obtaining unit that obtains a first image
photographed through an optical system and a second image
photographed under optical conditions different from optical
conditions in which the first image is photographed; and

20   a correction unit that corrects a defect contained within
the first image or the second image by using the first image
and the second image.

53.   An image processing apparatus according to claim 52,

25 wherein:

the first image and the second image are photographed under different optical conditions with regard to at least either of an aperture value and a pupil position.

54. An image processing apparatus comprising:

an image obtaining unit that obtains a photographic image captured with an image sensor;

a flat portion extraction unit that extracts a flat portion area within the photographic image having been obtained; and

a defect information generating unit that generates defect information corresponding to the extracted flat portion area.

55. An image processing apparatus according to claim 54, further comprising:

a correction unit that corrects an image within the flat portion area based upon the defect information.

56. An image processing apparatus according to claim 54 or claim 55, wherein:

the defect information corresponding to the flat portion area is generated based upon a value at a target pixel and an average value of a plurality of pixel values corresponding to pixels present within a predetermined range containing the

target pixel in the image within the flat portion area.

57.   An image processing apparatus according to claim 56,
wherein:

5   the defect information generating unit includes a
relative ratio calculation unit that calculates a relative
ratio of the value at the target pixel and the average value
of the plurality of pixel values corresponding to the pixels
present within the predetermined range containing the target
10   pixel, and generates the defect information corresponding to
the flat portion area based upon the calculated relative ratio.

58.   An image processing apparatus according to claim 55,
further comprising:

15   a relative ratio calculation unit that calculates a
relative ratio of a value at a target pixel and an average
value of pixel values corresponding to a plurality of pixels
present within a predetermined range containing the target
pixel, among pixels constituting an image of the flat portion
20   area, wherein:
the defect information generating unit generates the
defect information corresponding to the flat portion area based
upon the relative ratio having been calculated; and
the correction unit uses a reciprocal of the relative
25   ratio corresponding to a pixel in the image of the flat portion

area when correcting a value of the corresponding pixel in the image of the flat portion area by multiplying the pixel value by the reciprocal.

59. An image processing apparatus according to claim 58, wherein:

the correction unit executes low pass processing on the relative ratio which has been generated as the defect information and corrects the value of the corresponding pixel in the image of the flat portion area by multiplying the pixel value by a reciprocal of the relative ratio having undergone the low pass processing, which corresponds to the pixel in the image of the flat portion area.

60. An image processing apparatus according to any of claims 54 through 59, wherein:

the flat portion extraction unit executes edge extraction within the photographic image and extracts an area in which no edge is extracted as a flat portion area.

61. An image processing apparatus according to claim 54, wherein:

the flat portion extraction unit includes a gradation conversion unit that executes gradation conversion on the photographic image and executes a flat portion area extraction

on the photographic image having undergone the gradation
conversion.

62.   An image processing apparatus according to claim 61,
wherein:

    when gradation of the photographic image is indicated
with a linear signal, the gradation conversion unit converts
the linear signal to a nonlinear signal.

63.   An image processing apparatus according to claim 62,
wherein:

    the gradation conversion unit executes conversion by
enlarging the gradation on a low intensity side and compressing
the gradation on a high intensity side.

64.   An image processing apparatus according to claim 62 or
claim 63, wherein:

    the gradation conversion unit executes conversion by
using a power function.

65.   An image processing apparatus according to claim 64,
wherein:

    the power function is a square root function.

66.   An image processing apparatus according to any of claims

60 through 65, wherein:

the edge extraction is executed by calculating differences corresponding to a plurality of distances between a target pixel and surrounding pixels along a plurality of

5   directions.

67.   An image processing apparatus according to any of claims 55, 58 and 59, further comprising:

a luminance level decision-making unit that makes a

10   decision as to whether or not a luminance level of the photographic image is equal to or higher than a predetermined luminance level, wherein:

the correction unit executes correction for an area determined to be a flat portion area, where the luminance level

15   is equal to or greater than the predetermined level.

68.   An image processing apparatus according to claim 54, further comprising:

a reference image obtaining unit that obtains a reference

20   image captured with the image sensor; and

a reference image defect information generating unit that generates defect information corresponding to the reference image, wherein:

the defect information generating unit generates the

25   defect information corresponding to the flat portion area by

using area information included in the defect information for the reference image and area information corresponding to the flat portion area in combination.

5   69.   An image processing apparatus according to claim 68, wherein:

if an area that is not extracted as the flat portion area is still indicated to be a defect area by the defect information for the reference image, the flat portion

10 extraction unit extracts the defect area as a flat portion area.

70.   An image processing apparatus according to claim 68 or claim 69, wherein:

15   the defect information generating unit generates the defect information for an area indicated as a defect area by the defect information for the reference image and also determined to be the flat portion area.

. 20 71.   An image processing apparatus according to claim 68, further comprising:

a defect information conversion unit that converts the defect information for the reference image to defect information equivalent to defect information for a reference

25 image photographed under optical conditions identical to

optical conditions under which the photographic image has been
photographed when the photographic image and the reference
image have been photographed under different optical
conditions, wherein:

5   the correction unit uses the defect information for the
reference image resulting from the conversion.

72.   An image processing apparatus according to claim 69 or
claim 70, further comprising:

10   a defect information conversion unit that converts the
defect information for the reference image to defect
information equivalent to defect information for a reference
image photographed under optical conditions identical to
optical conditions under which the photographic image has been
15   photographed when the photographic image and the reference
image have been photographed under different optical
conditions, wherein:

the flat portion extraction unit and the correction unit
use the defect information for the reference image resulting
20   from the conversion.

73.   An image processing apparatus according to claim 71 or
claim 72, wherein:

in consideration of an error in defect information
25   conversion executed by the defect information conversion unit,

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the correction unit expands the defect area indicated by the defect information for the reference image, at least by an extent corresponding to the error in the defect information conversion.

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74.   An image processing apparatus according to claim 54, wherein:

the image obtaining unit obtains a plurality of photographic images captured with the image sensor;

10   the flat portion extraction unit extracts the flat portion area in each of the plurality of photographic images; and

the defect information generating unit generates defect information corresponding to the flat portion area in one of

15   the plurality of images by using images of flat portion areas in the plurality of images having been extracted.

75.   An image processing apparatus according to claim 54, wherein:

20   the image obtaining unit obtains a plurality of photographic images captured with the image sensor;

the flat portion extraction unit extracts the flat portion area in each of the plurality of photographic images; and

25   the defect information generating unit generates defect

information corresponding to an entire image of each of the plurality of images by using images of flat portion areas in the plurality of images having been extracted.

5   76.   An image processing apparatus according to claim 74 or claim 75, wherein:

the defect information corresponding to the flat portion area is generated based upon a value at a target pixel and an average value of a plurality of pixel values corresponding
10   to pixels present within a predetermined range containing the target pixel in the image within the flat portion area.

77.   An image processing apparatus according to claim 76, wherein:

15   the defect information generating unit includes a relative ratio calculation unit that calculates a relative ratio of the value at the target pixel and the average value of the plurality of pixel values corresponding to the pixels present within the predetermined range containing the target
20   pixel, and generates the defect information corresponding to the flat portion area based upon the calculated relative ratio.

78.   An image processing apparatus according to claim 69, wherein:

25   if there are a predetermined number of pixels or more

pixels from which an edge has been extracted are present around the defect area indicated by the defect information for the reference image, the flat portion extraction unit does not extract the defect area as the flat portion area.

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79.   An image processing apparatus according to claim 78, wherein:

if an edge has been extracted from a majority of pixels among pixels present in a predetermined area surrounding a pixel in the defective area, the flat portion extraction unit does not extract the pixel in the defect area as a pixel in the flat portion.

80.   A computer-readable computer program product having an image processing program enabling a computer to execute functions of an image processing apparatus according to any of claims 1 through 79.